E-Mining@School; A Cross-Curricular Initiative To Embed Sustainability In The Junior Cycle Curriculum

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Abstract

Secondary level education in Ireland is going through a major transition with the introduction of the new Junior Cycle programme. For the first time sustainability is being embedded into every subject and teachers have been given the opportunity, and flexibility to create their own curriculum

Addressing this, 8 teachers at Castletroy College worked collaboratively on the "E-Mining@School" project to incorporate sustainability into their subjects' curriculum using an ambitious multidisciplinary approach. This approach attempted to connect sustainability to the student's everyday lives through the product that teenagers covet the most; their smartphones. The project developed a collaborative cross-curriculum pilot that explored the common theme of 'urban mining of e-waste for Critical Raw Materials (CRMs)' and the teachers integrated this common theme into the curriculum of 5 subjects that included Science, Geography, Business, Technology, and Civic, Social and Political Education (CSPE) that would be delivered concurrently.

The pilot ran for 4 weeks, beginning at the end of January 2019. A cohort of 220 2nd year students attended 60 lessons over all 5 subjects. 24 teachers delivered these lessons and each student received, on average, over 38 hours of lessons. The project culminated in a public WEEE collection event that recovered over 11 tonnes of WEEE that was sent for recycling. The second running took place in the Spring of 2020 and it is planned to continue it as an annual endeavour.

The pilot demonstrated to students the value of the resources used in their electronic products and the challenges of finite resource scarcity. It showed them not only where their stuff came from but also where it goes when they thought it thrown it away. Through the project students became familiar with and champions of the Circular Economy which was very evident in the WEEE collection event. The project was also the first occasion for the teachers to collaborate on a cross-curricular approach to secondary education and the paper includes findings on this topic.

1 Introduction to the Junior Cycle

The Framework for Junior Cycle (2015), outlines the key educational changes that the Department of Education and Skills (DES) Ireland is putting in place for young people in the first three years of their post-primary education. It outlines a vision of teaching, learning and assessment that supports inclusive, quality and relevant education for the young people of Ireland.

A major change for subject teachers as they moved from the Junior Certificate (1989) to the Junior Cycle (2015) was a move from a content driven syllabus to a learning outcomes-based specification. Each Junior Cycle subject specification consists of a series of learning outcomes. Subject teachers are encouraged to plan units of work to include a number of learning outcomes to give students a deeper understanding of the relationships and connections that exist between various elements of each subject specification. The development of 8 key skills are central to the learning that happens in Junior Cycle and beyond school. These key skills are embedded by a series of actions verbs in the learning outcomes of each subject specification.

The learning outcomes are broad and non-specific which gives teachers a degree of autonomy and flexibility to decide how best to ensure students achieve the intended learning. This autonomy has caused a degree of challenge to teachers across the country as they grappled with issues like depth of treatment and debated what should and should not be included as learning in each learning outcome.

2 EIT KIC Raw Materials Project

In March 2018, a team from the Dept of Electronic and Computer Engineering approached the school looking for a project partner to work on the design and delivery of an educational package aimed to raise awareness among students about critical raw materials in e-waste. This EIT Raw Materials funded project included partners from 5 European countries each aiming to work collaboratively with 2nd level educational institutions on this learning and education project. One aim of this project was to 'teach the teacher' so that 2nd level educators would be empowered to deliver aspects of this project moving forward without the continued support of the project partners.

The project aimed to teach students about raw materials and life cycle issues, e-waste management and recycling, raw materials business opportunities, entrepreneurship as well as a range of skills to include communication, working together and planning and organising a collection event.

This project coincided with unit planning in the area of sustainability within subject departments in school so it was an opportune time for teachers across a number of subject departments to come together and design a unit of work on the areas of sustainability but with the support of a research group or experts in the area from University of Limerick and on the common theme of critical raw materials. Students learning about sustainability in their use of mobile phone from the perspective of the different subject specifications would enable students to make meaningful and progressively more challenging connections between learning in different subjects.

A project coordinator was nominated, and a team of 7 interested teachers was put in place from five subject areas. The subject involved included science, business, geography, CSPE and metalwork.

3 Unit Planning Across Subjects

Unit planning commenced in September 2018 with members of the core design team meeting regularly in their free time, during lunch or during times allocated by school management. The process took a number of steps and will be outlined below.

1. Each subject area identified a number of learning outcomes that could be used to link around the topic of electronics and sustainability
2. Input was sought from UL on the area of critical raw materials. This subject matter was new to most members of the team and expertise was required to ensure common understanding of the topic as a whole.
3. Each subject department identified learning intentions related to the area of critical raw materials that would outline the intended learning in each of our learning outcomes.
4. Once the key learning was agreed in each of the subject areas, the team looked for common themes and arranged the learning on a weekly thematic basis.
5. Teachers then designed a range of student centred lessons which included learning activities that afforded students to take ownership and responsibility of their learning and that would develop a range of key skills as outlined by the Junior cycle framework.
6. Opportunities for students to reflect on their learning and in how they learn were deliberately embedded in the design of the module with the inclusion of a student learning log. Here students were able to identify the key learning in each of the subject per week as well as facilitated to make connections between the learning in each of the different subject areas.

4 Common Theme of Critical Raw Materials

The common theme of **Critical Raw Materials (CRM)** in smartphones was chosen for its relevance to students' everyday life given how dear phones are to teenagers.

The teachers defined their chosen theme as

> *Our stuff is made of stuff.*
>
> *Our appetite to have new stuff appears to be unbounded. Billions of people around the world aspire to our standards of living and consumption. We never think about where the materials for our stuff come from and whether or not they will always be available to us in the future. Where do they come from? How are they mined/extracted? Why do we use the specific materials that we do? Where does our stuff end up?*
>
> *The way we currently use materials is very wasteful and has complex environmental, social and economic consequence both now and for the future.*
>
> *We need to move from this 'take-make-dispose' linear economy to a circular economy where materials are used multiple times. How do we do this? What is involved?*
>
> *During this programme of study, students will study the origin, properties, uses of various metals, the environmental, social and economic consequences of our current practices in terms of origin and disposal of wastes and potentially develop newer and more sustainable business models*

4.1 Critical Raw Materials

The European Union (EU) began identifying CRMs in 2010 after China set very tight export quotas for certain raw materials. This drove the EU to conduct a review of risks to the European economy in the event of a raw material shortage. This review resulted in the creation of a list of Critical Raw Materials (CRMs). CRMs are chemical elements identified by the EU based on three criteria that include:

1. being significantly economically important to key sectors in the European economy such as; medical; defence; low carbon technologies; consumer electronics and automotive.
2. having a highly risky supply from the likes of; trade wars; a lack of available mining reserves; rapid increase in demand for new technologies or wars in areas rich in ore deposits.
3. a lack of (viable) substitutes in their important applications.

Table 1 2017 List of Critical Raw Materials

EUs 2017 list of CRMs						
Antimony	Bismuth	Fluorspar	Helium	Magnesium	PGMs	Silicon metal
Baryte	Borate	Gallium	HREEs	Natural graphite	Phosphate rock	Tantalum
Beryllium	Cobalt	Germanium	Indium	Natural rubber	Phosphorus	Tungsten
	Coking coal	Hafnium	LREEs	Niobium	Scandium	Vanadium

The EU uses this list of CRMs to put policies and measures in place to alleviate the risk of material shortages or price increases. Measures they are looking at include new European mines, research into material substitutes and the creation of a Circular Economy in Europe.

The primary sources (virgin raw materials) of CRMs may be restricted due to

- geographical deposit, concentrated levels and diminishing reserves
- a lack of historical investment in material processing abilities
- only being extracted from the waste streams of mines that primarily mine other materials.

4.2 Circular Economy

Another potential source of CRMs is in existing products that are no longer used. The CRMs in existing products has already been mined, processed, produced into a product and even could have already been discarded. This is known as the Linear Economy of ‘Take - Make – Dispose’. A circular economy aims to recover CRMs in circulation (in existing products), so they can be recycled into new products. A Circular Economy aims to reduce the need virgin materials and new mines. Likewise, a Circular Economy could enable the EU to reduce dependence on the import of CRMs and thus reducing the risk to parts of its economy that rely on CRMs.

The availability of CRMs above ground will vary greatly depending on the material's application and history. Some materials will be locked up in long life products such as wind turbines. While others will be available in abundance in short life products like electronics. However, the biggest challenge is accessing these materials in an economically viable manner.

Once the topic of critical raw materials was understood by the teacher design team, it was then broken down as specific learning in each of the five subject areas that would achieve the learning outcomes in each of the subject specification.

This breakdown is outlined briefly in table 2.

Table 2 Overview of Learning Outcomes for Subjects Over the Course of the E-Mining@School Project

Subject	**Week 1**	**Week 2**	**Week 3**	**Week 4**
Science	Define the term element, mixture and compounds, metals and non-metals and list their properties. Explain how the elements used in mobile phones have changed over the past decade. Work in groups to plan, design and carry out an investigation to determine if a material is an insulator or conductor of heat and electricity.	Introduce and discuss the concept of critical raw materials. Identify raw materials that are essential in manufacture of smart phones. Research and prepare a poster for presentation on one critical raw material.	Define energy and identify 5 different forms of energy Calculate the energy used while caring my mobile phone. Identify what my phone needs to interact with in order to function. Working in groups, analyse data from our student survey and identify patterns and trends in our phone use.	Appreciate the scale and impact of electronic waste and the dangers of human toxicity. Identify and list the advantages and disadvantages of our current systems for dealing with electronic waster. Discuss roles that can be taken to help organise a WEEE collection event.
Geography		Identify how natural resources can be extracted from the earth. Discover where resources can be found around the world. Describe the process of drilling, shaft mining and quarrying. Identify the advantages and disadvantages of quarrying.	Identify uses of cobalt. Compare how cobalt is extracted in the Democratic republic of Congo to how zinc is extracted in Navan, Co. Meath. Understand how natural gas is exploited in Ireland. Begin to understand how the exploitation of resources can become controversial over time.	Use the definition of sustainable development created in CSPE class and apply it to the exploitation of natural resources. Identify ways in which exploited mines can be used sustainably.
CSPE	Consider a variety of definitions of development and devise their own definition of sustainable development. Introduction to the UN Sustainable development goal 12: ensure sustainable consumption and production patterns.	Identify how UN SDG 12 can be linked to the issue of critical raw materials. Analyse a global issue-unsustainable consumption and production of critical raw materials.	Identify the impacts of electronic waste. Discover how electronic waste impacts on the lives of people in Ghana and China. Compare and analyse information. Identify possible solutions to the challenge of	Evaluate how I contribute to reduction the unsustainable consumption and production of critical raw materials. Identify waste materials in my environment that I can contribute to the waste recycling event. Work as part of a team to organise a waste collection event.

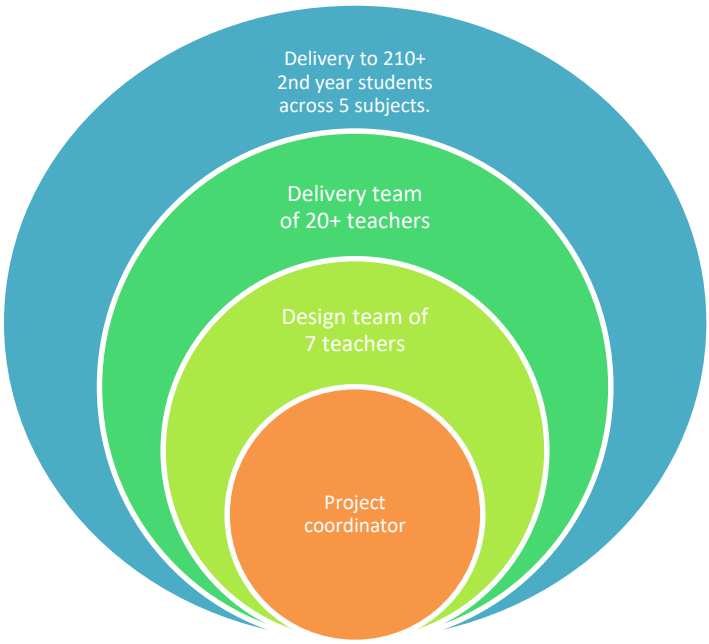
	Understand the term ecological footprint.		unsustainable consumption of CRMs.	
Business	Explain the term 'economic resources. Identify and explain each of the factors of production. Explain the term scarcity. Be able to distinguish between needs and wants. Explain how scarcity, choice and opportunity costs for individuals, companies and governments.	Discuss and compare economic systems. Centrally planned e.g. China, free market, USA and mixed economy, Ireland. Understand different sectors of the economy and identify the sectors that recycling companies work in. Explain how the different sectors interact.	Explain and distinguish between a closed economy and an open economy. Outline the importance of imports and exports for a country. Understand the factors of production. Begin to understand the importance of the government recognising the sustainability of resources.	Understand factors affecting demand and factors affecting supply. Understand a business plan and its importance to business. Understand the importance of sustainability. Discuss ethical business behaviours. Explain the term marketing. Explain the reasons for advertising. Plan for the marketing and advertising of the WEEE collection event.
Engineering.		***Break is down*** Explain how design impacts on the function and quality of a product. Examine modern technologies, how they are designed and manufactured. Look at the role of CRMs in modern technologies. Students analyse the impact a disruption in supply of CRMs would have on the production of modern technologies.	***Pick it apart*** Examine products design intent. Assess a product's intended life cycle. Evaluate the sustainability of a products design. Students will compare products with differing intended life cycles and discuss the sustainability of each.	***Build it up.*** Design a new product concept with a more sustainable life cycle.

5 Delivery – Moving to a Wider Team

Once the unit outline had been agreed and lesson plans and resources designed it was handed over to a wider team of delivery teachers. There are 7 base classes in each group so a team of over 20 teachers were required to deliver the unit to all 7 base classes in each of the five subject areas. 210+ second year students were taught this interdisciplinary unit over four weeks in January/February 2019 and again in January/February 2020.

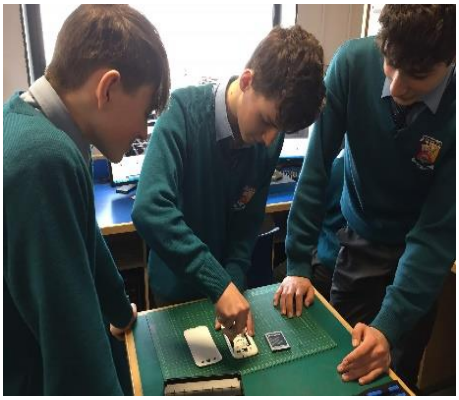
Input and feedback had been sought from the wider delivery team numerous times during the design phase so that the rationale was clear and understood by all and all teacher felt a degree of ownership of the final product. The structure of the various partners is outlined in the diagram below.

Figure 1 Illustration of the Project Delivery



A google classroom for the teacher design and delivery teams was set up to share all resources and also to ensure good communication and sharing of ideas, progress and indeed challenges before, during and after delivery. The unit was delivered over a 4-week period and teachers were encouraged to complete a learning log at the end of each week. This ensured that classroom activities and strategies that worked well were logged and also connections that students made between learning each of the subject areas was identified. These reflections would form the basis of the evaluation of the unit at the end of delivery.

Figure 2 Sample of Photos from Project Activities

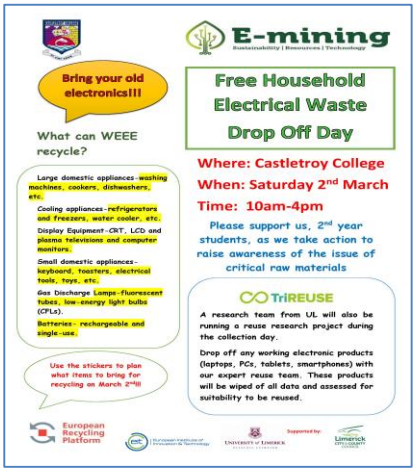


6 Impact Based on Evidence

Surveys were conducted before and after delivery with both with teachers and students. Feedback from these surveys was overwhelmingly positive. Students indicated that they felt that they got a rich and deep understanding of sustainability from all the pillars by learning about it concurrently in various subject areas. Students were interested in engaged in classes and the relevance of the topic to them and their lives helped in sustaining their interest and enthusiasm. Teachers reported that students were well able to take part in detailed discussions in classroom and connected and understood learning that happened on the topic in other subject areas. Teachers themselves felt that they learnt more about the subject areas through these detailed and informed discussion with students.

A group of students from the 2nd year cohort formed a core organising team and worked hard marketing and planning the WEEE collection event which was held in the school grounds a few weeks after delivery ended. The event was a huge success with 11tonnes of electronic waste dropped off for recycling on the day. Students turned up on the day and carried out a range of jobs such as logging number of cars as well as keeping an inventory the various items that were being dropped for recycling. Students exhibited great interest and enthusiasm and were hugely proud of their efforts in collecting so much WEEE for recycling.

Figure 3 Selection of Photo's from WEEE Collection Event



7 Conclusion

Sustainability is a key element in a number of different subject specifications in the new Junior Cycle. Various aspects of sustainability are addressed in the different subject areas for example economic sustainability in Business and environmental sustainability in CSPE and Geography. Traditionally teachers would work with their subject departments and agree a scheme of work for the year, not knowing what was being taught in other subject areas or when.

In this project, teachers of five subject areas came together and planned a unit of work that would be delivered concurrently to provide students with an ability to make meaningful and progressively more challenging connections between learning in different subjects on the area of sustainability. The hope was the students would have a richer educational experience and a deeper understanding of the topic in questions.

Feedback from both students and teachers' surveys and focus groups would indicate that deeper learning and understanding happened and that students found the process engaging and interesting.

The process was challenging and time consuming and it was the first-time planning like this happened in our school or indeed in the majority of school around the country. There ae huge benefits to students in this type of design and delivery and it will be an approach we will explore with other subject areas moving forward in our school. We are confident that our topic of sustainability is truly understood and embedded by our students and they have gained a deep understanding and can think critically about the complexity of all the pillars of the topic of sustainability.

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- European Recycling Platform; Charlotte Budd, Yvonne Holmes

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